The Hard X-Ray Nanoprobe at PETRA III Beamline P06

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The PETRA III beamline P06 provides two experimental hutches, one hutch for microprobe applications (micro hutch) and a second one for nanoprobe experiments (nano hutch). In close cooperation with the P06 staff and with financial support of the BMBF (Bundesministerium für Bildung und Forschung), our study group at the Institute of Structural Physics, TU Dresden developed, built and installed the nanoprobe setup of the nano hutch [1]. The instrument was installed during the summer of 2010, and there has been beam inside the nano hutch since November 2010.
As shown in Figure 1, the nanoprobe instrument consists of two spatially separated parts. The scanner unit stands on the top of a massive block of granite and contains the focusing optics, the stages for optics alignment, the sample stages, the slits, and the pinhole. The large detector table carries a detector revolver charged with a high-resolution x-ray camera, a CCD diffraction camera, a Pilatus diffraction pixel detector, a visible light microscope, and a calibrated PIN diode. Each detector can be moved inside the beam without any mechanical replacement, just moving the large rotation stage to a certain angle. This detector concept gives flexibility to the greatest possible extent and saves much time during the experiments. An energy-dispersive drift detector records the fluorescence radiation from an angle of $90°$ to the optical axis, this way minimizing background due to elastic and inelastic scattering from the sample. The hard x-ray scanning microscope can be operated at photon energies between 5 and 80 keV and generates nanobeams of size between 40 and 100 nm FWHM.

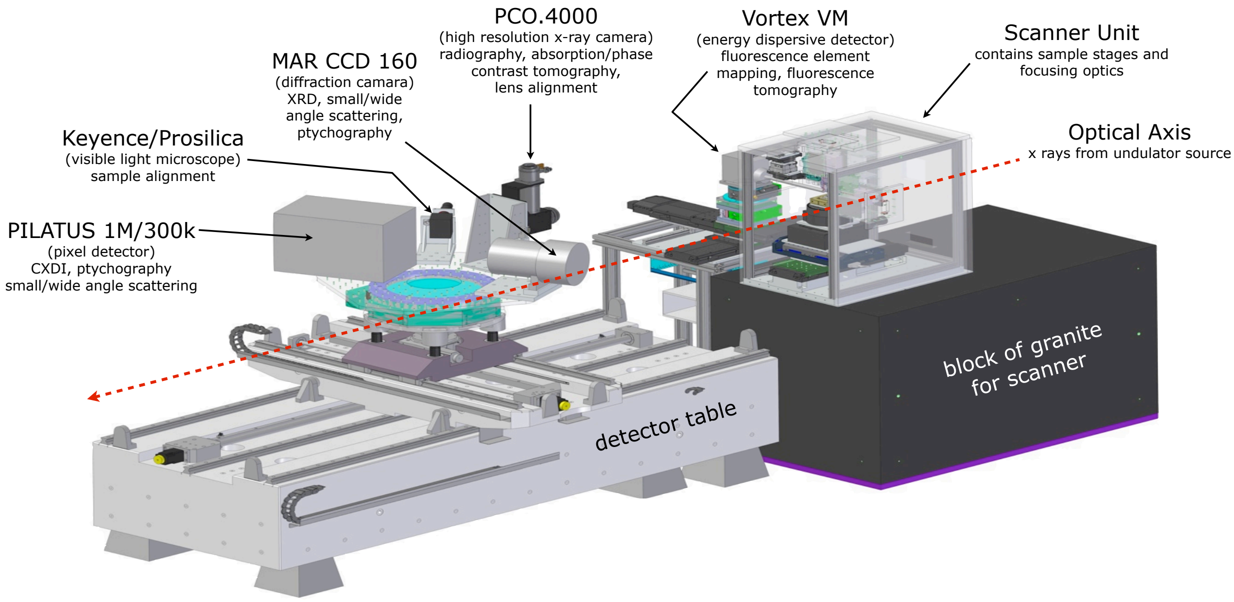

Figure 1: Schematic drawing of the nanoprobe instrument.

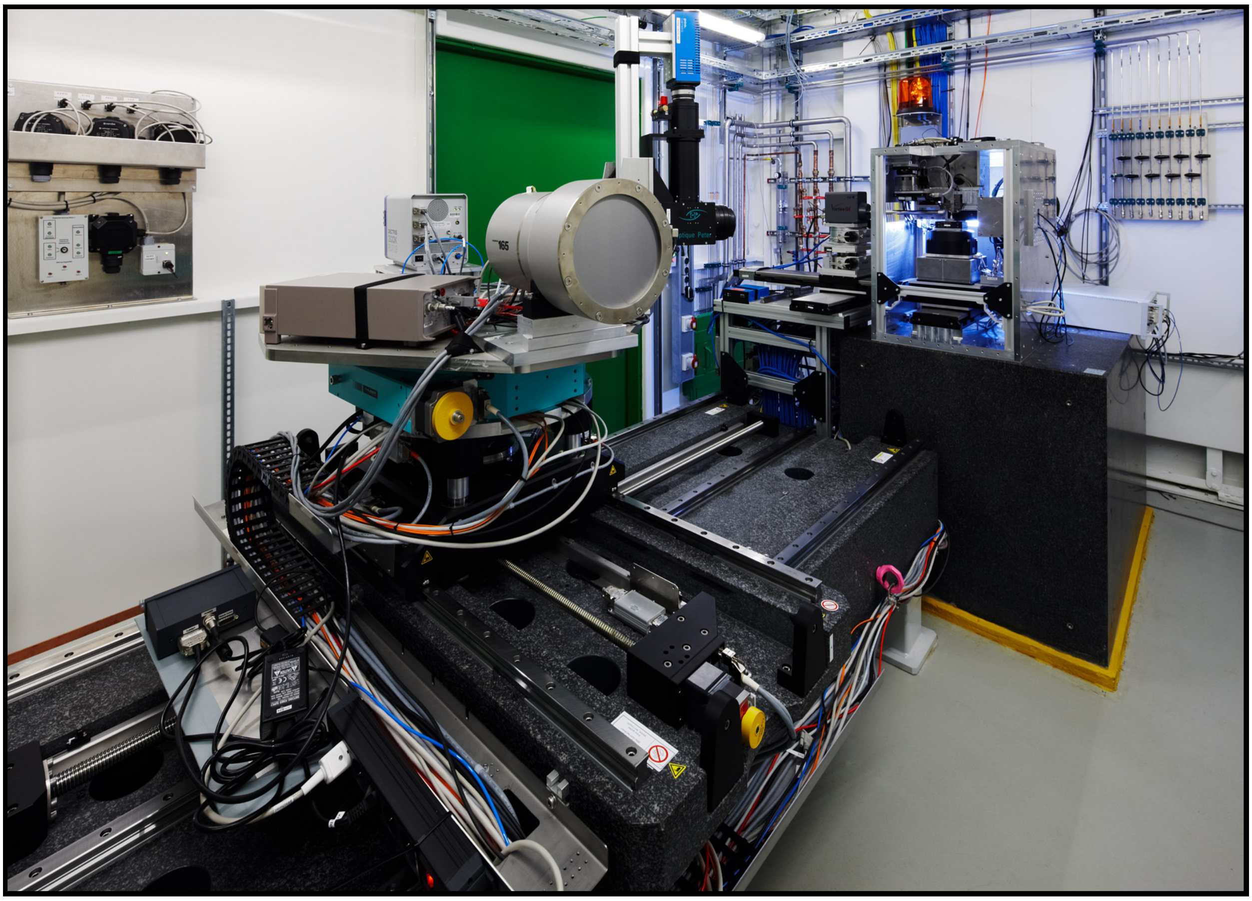

Figure 2: Photograph of the nanoprobe hutch.

The nanoprobe is capable of a large variety of investigation methods, exploiting many different contrast mechanisms like x-ray fluorescence, elastic and inelastic scattering, diffraction with coherent and partially coherent illumination, absorption contrast and phase contrast, x-ray absorption spectroscopy, and so on.
In the year 2011, numerous experiments were performed in the nano hutch during the commissioning of the instrument. Nearly all of them were carried out or at least were supported by our group participating at the experiments. Among others, we did full-field absorption tomography with biological samples, fluorescence element mapping and fluorescence tomography with biological and anorganic specimens, scanning coherent x-ray diffraction imaging (ptychography) for beam characterization and ptychography to investigate the inner structure of samples with spatial resolution well below the beam size. In addition, we tested diverse focusing x-ray optics like nanofocusing refractive lenses (NFL), Fresnel zoneplates (FZP), and Multilayer-Laue-Lenses (MLL). We developed and tested new microscopy methods, combining scanning ptychography with x-ray absorption spectroscopy (XAS), notably with x-ray absorption near-edge spectroscopy (XANES) and combining ptychography with tomography (tomographic ptychography). Publications reporting the results are in preparation.

References

[1] C. G. Schroer, P. Boye, J. M. Feldkamp, J. Patommel, D. Samberg, A. Schropp, A. Schwab, S. Stephan, G. Falkenberg, G. Wellenreuther, and N. Reimers, Nucl. Instrum. Meth. A **616**, 93 (2010).